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# Major hydrogeochemical processes in the two reservoirs of the Yangbajing geothermal field, Tibet, China

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**Abstract**

The Yangbajing geothermal field with the highest reservoir temperature in China is located about 90 km northwest to Lhasa City, capital of Tibet, where high temperature geothermal fluids occur both in shallow and deep reservoirs. The geophysical survey by the INDEPTH (International Deep Profiling of Tibet and the Himalayas) project group proved the existence of magmatic heat source at Yangbajing. In the study area, the hydrochemistry of cold surface waters and groundwaters and that of thermal groundwaters from both reservoirs are distinctively different. However, analysis of the relationship between enthalpy values and Cl concentrations of cold groundwaters and geothermal fluids indicates that the geothermal fluids from the shallow reservoir were formed as a result of mixing of cold groundwaters with geothermal fluids from the deep reservoir. In other words, the geothermal fluids from the deep reservoir flowed upwards into the shallow reservoir where it was diluted by the shallow cold groundwaters to form the shallow geothermal fluids with much lower temperature. A binary mixing model with two endmembers (the cold groundwaters and the deep geothermal fluids) was proposed and the mixing ratios for the geothermal fluid from each shallow well were estimated. Using the mixing ratios, the concentrations of some constituents in shallow geothermal fluids, such as As, B, $SiO_2$, $SO_4^{2-}$ and F, were calculated and their differences with the actual concentrations were estimated. The results show that the differences between estimated and actual concentrations of As and B are small (the average absolute values being only 1.9% and 7.9%, respectively), whereas those of $SiO_2$, $SO_4^{2-}$ and F are much bigger, indicating that other hydrogeochemical processes are responsible for the concentrations of these constituents. It is postulated that $SiO_2$ precipitation due to water temperature decrease, $H_2S$ oxidation and ion exchange between $OH^-$ in geothermal waters and exchangeable $F^-$ in fluoride bearing silicate minerals during the geothermal fluid upflow might be the causes for the observed concentration differences.


*Keywords:* geothermal fluid; reservoir; hydrogeochemical process; magma degassing; mixing; the Yangbajing geothermal field

## 1. Introduction

It has been commonly accepted by the international geothermal community that high temperature geothermal systems are usually distributed along plate margins, with local melts of upper mantle or lower crust as heat

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source. For continental high temperature geothermal systems with magma as heat source, water vapor and other chemical constituents released from degassing magma may constitute the important source for geothermal fluids, although rainfall is the major recharge source in many cases. In recent years, understanding the sources of high temperature geothermal fluids and its dissolved constituents and the geochemical processes occurring in reservoir has become a hot topic for geothermal studies (Sheppard and Lyon, 1984; Marty et al., 1991; Hilton et al., 1993; Menuge et al., 1997; Clark and Phillips, 2000; Aguilera et al., 2005; Gherardi et al., 2005). Interaction between high temperature hydrothermal system and cold water system has also attracted the attention of researchers (Tenu et al., 1981; Delmelle et al., 1998; Brombach et al., 2000).

Yangbajing, located to the northwest of Lhasa city, Tibet, western China (Fig. 1-a), is a geothermal system with the highest reservoir temperature in China, the

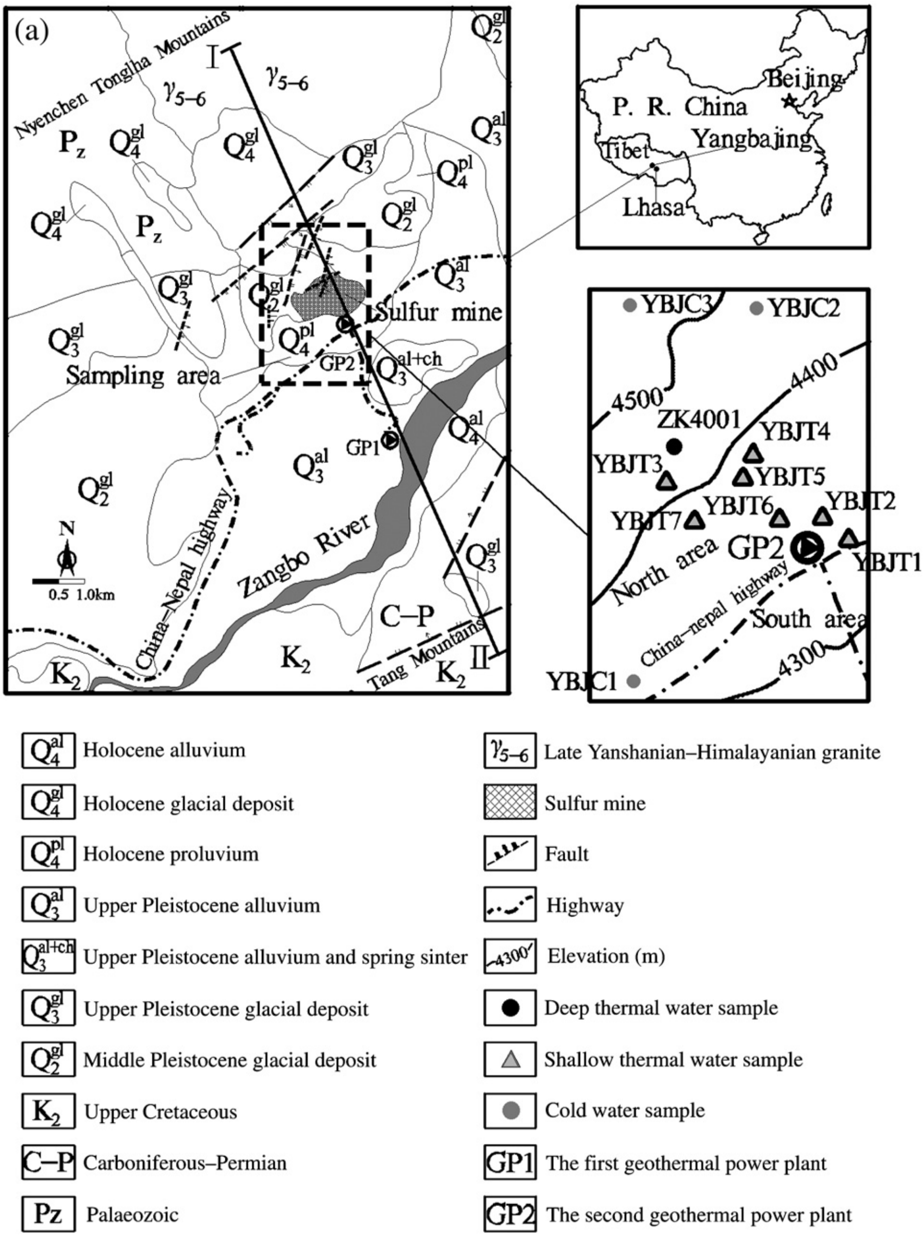


Fig. 1. Simplified geological map of the study area and sampling locations (a); Geological cross section along the I–II line (b).